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AIRCRAFT STRUCTURAL TESTS

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WASHINGTON SEPTEMBER 1965

AIRCRAFT STRUCTURAL TESTS */i

32875

Technical specifications to accompany a request for proposal by the Toulouse Aircraft Plant of the French Ministry of Defense, to furnish equipment and supplies for static and thermal structural aircraft tests on the supersonic Mach-2 Concord, including analog and digital computer elements for in-test data reduction, power supply systems based on thyristors, kinetic heating simulators, control equipment, etc. Charts and diagrams of the overall project and floor plans of the construction hangars and testing rooms are included.

author

SUMMARY

The folder includes three portions:

I - Technical plans of the building: These layout sheets permit future users to design the loading equipment and implements on the basis of the indicated attachment points at the bottom of the jig or on the static testing panel, enabling them to know the forces that can be applied there.

These plans also show the overall dimensions of the building and its annexes.

II - Request for proposal on measuring and programming equipment: The technical specifications are based on the use of control elements of the electric power furnished by electric motors. The progress in present concepts in this particular field has been extremely rapid and extensive, as indicated in the third

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* Numbers in the margin indicate pagination in the original foreign text.

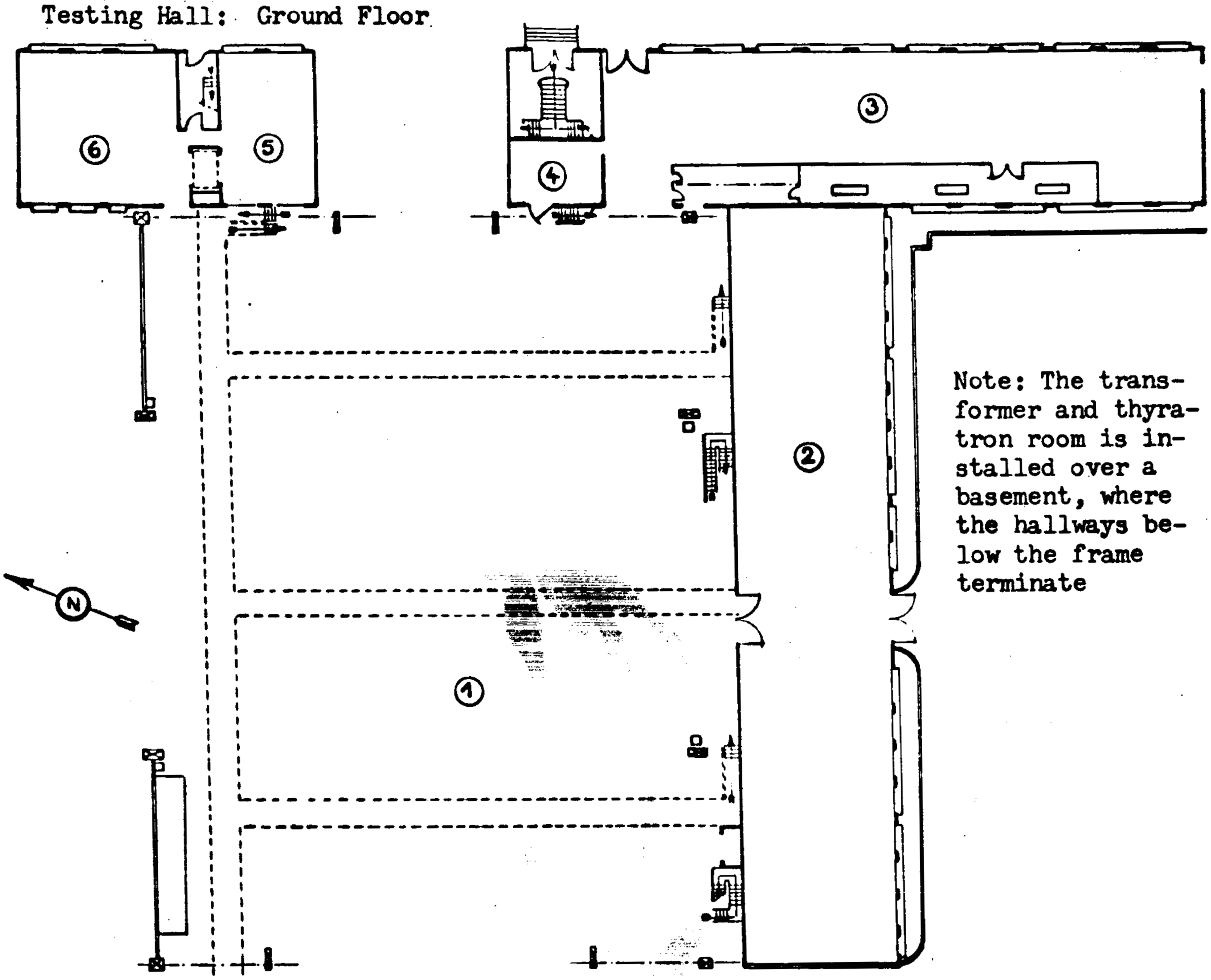
portion of this folder.

The number of measurements, for the time being, has been established at 2000 and any decrease relative to the figures contained in this request for proposal refers only to minor channels. The selected method of servicing and controls also differs considerably from that described in the request for proposal and specifies an incremental technique, with the incremental computer giving either one or two or four increments within one operating period.

III - Request for proposal for power-control equipment: This request refers to an installation on a thyristor base. The novelty of the command system is due to the increments furnished by the computer. The final total power of the installation will be 30,000 k-amp.

GROUP Hers Annex	Structural Static Tests (Mechanical and Thermal Loads)	EDITION :

Testing Hall: Ground Floor



Note: The transformer and thyratron room is installed over a basement, where the hallways below the frame terminate

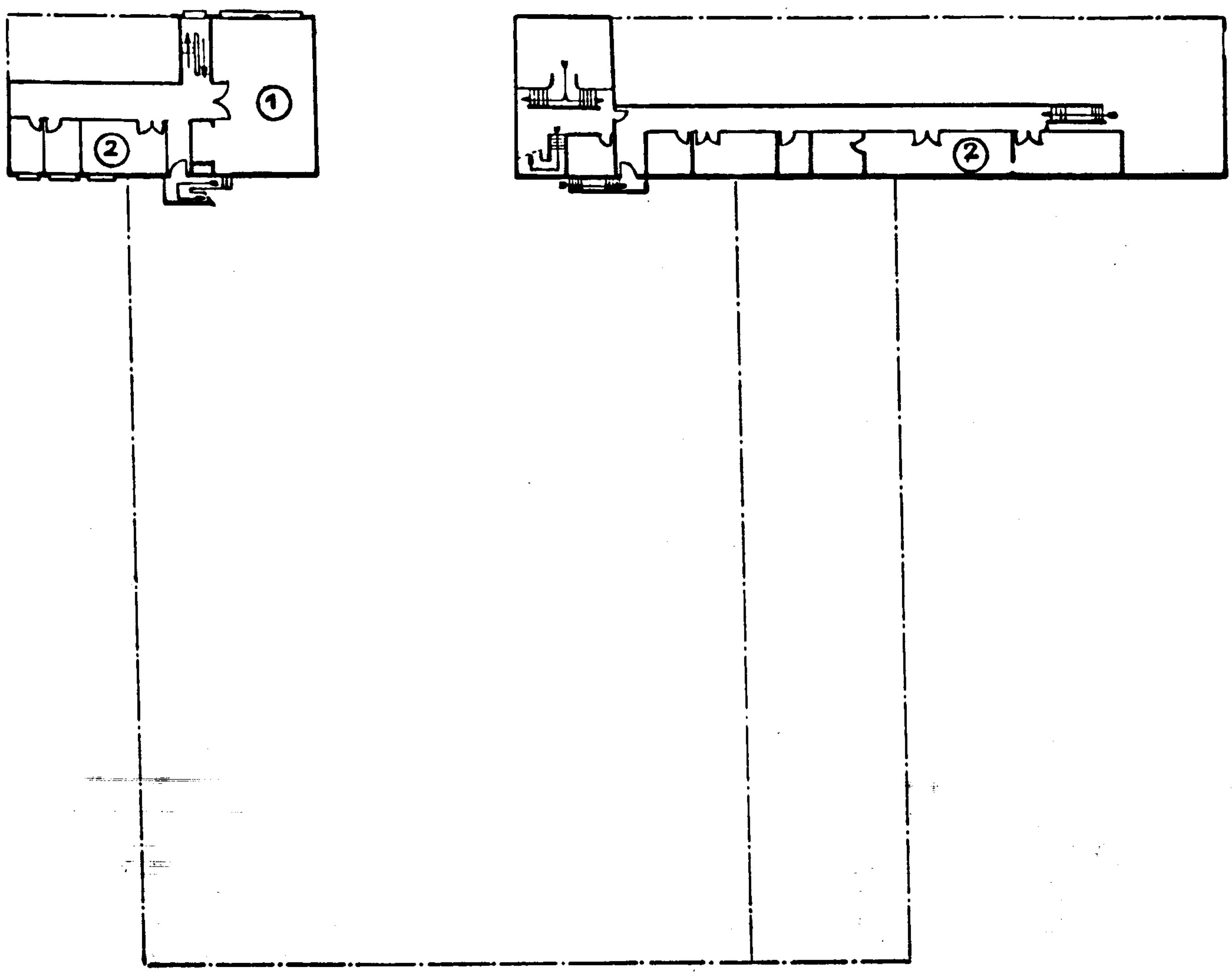
① Static testing room
② Transformer and thyratron room
③ General mechanics shop
④ Tool room
⑤ Hydraulic jacks and stockroom
⑥ Stockroom and spare parts

Scale: 1/600

Level: 0

EAT

ETABLISSEMENT AERONAUTIQUE DE TOULOUSE
23, Avenue André Guillaumet
Téléphone . 62.38.64



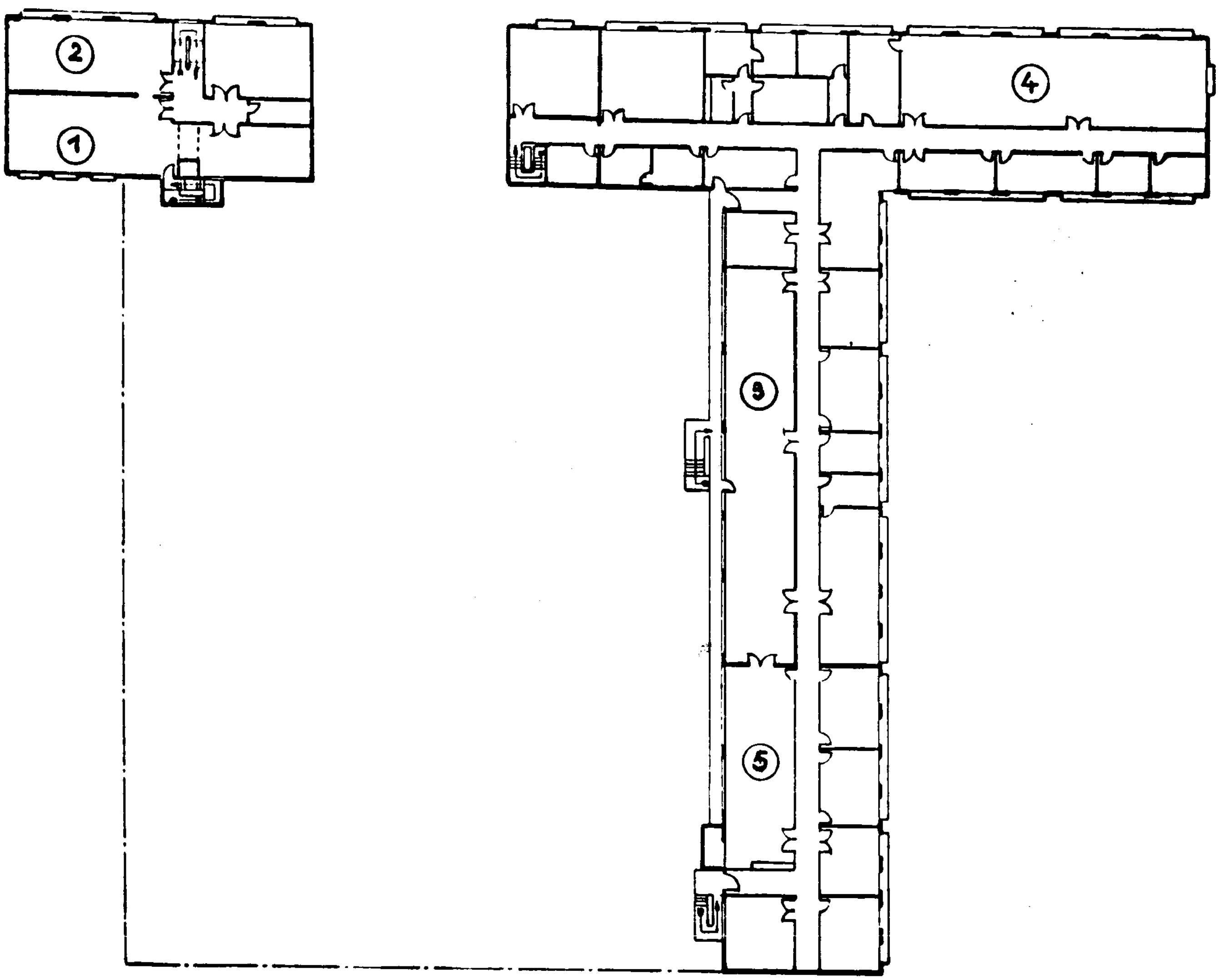
(1) Maintenance and stockroom

(2) Offices

Scale: 1/600

Level: 3.20 m

First Floor

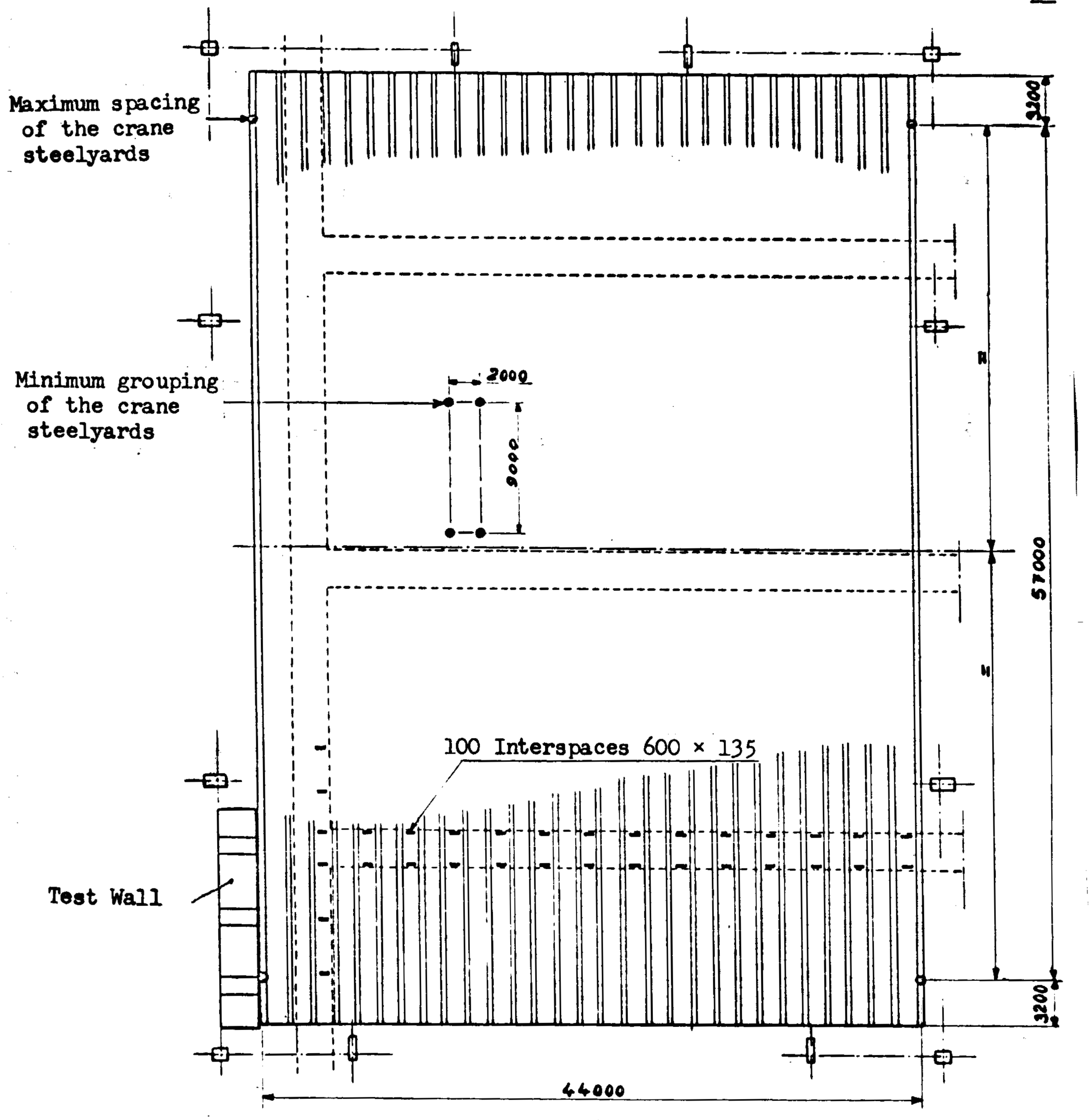


1	Measuring room
2	Data workup
3	Control room
4	Survey office
5	Laboratory

Scale: 1/600

Level: 7 m

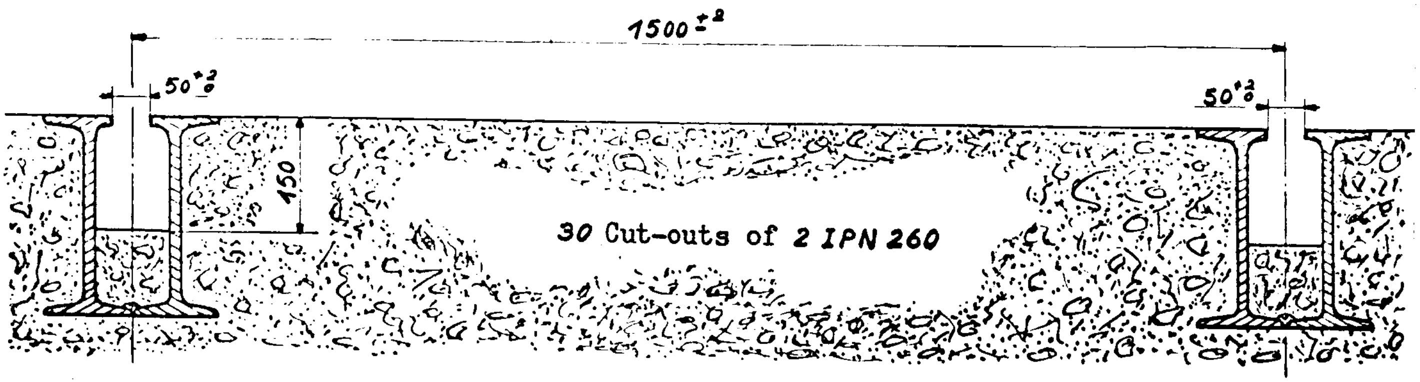
Second Floor



Traveling cranes: Number, 2; range, 46.5 m with two 10-ton trolleys per crane; clearance below steelyards: 20 m

Clearance under steelyards: 20,000 mm
Scale: 1/400

Testing Hall: Frame



1 - Admissible loads on the cut-outs

1.1 - Vertical loads toward the top (traction)

1.1.1 - Point loads: 2×10^5 Newtons.

1.1.2 - On one cut-out: 20 times 2×10^5 Newtons, spacing 2.00 m.

The two cut-outs next to the cut-out loaded in the above manner cannot be subjected to traction loads.

1.1.3 - On several adjacent cut-outs: 10 times 2×10^5 Newtons, spacing 1.50 m.

1.1.4 - On all cut-outs, the total traction load must not exceed 10^7 Newtons.

1.2 - Horizontal loads:

1.2.1 - Point loads: 2×10^5 Newtons.

1.2.2 - On one cut-out: 3 times 2×10^5 Newtons, spacing 1.50 m.

1.2.3 - On several adjacent cut-outs: 10 times 2×10^5 Newtons, spacing 1.50 m.

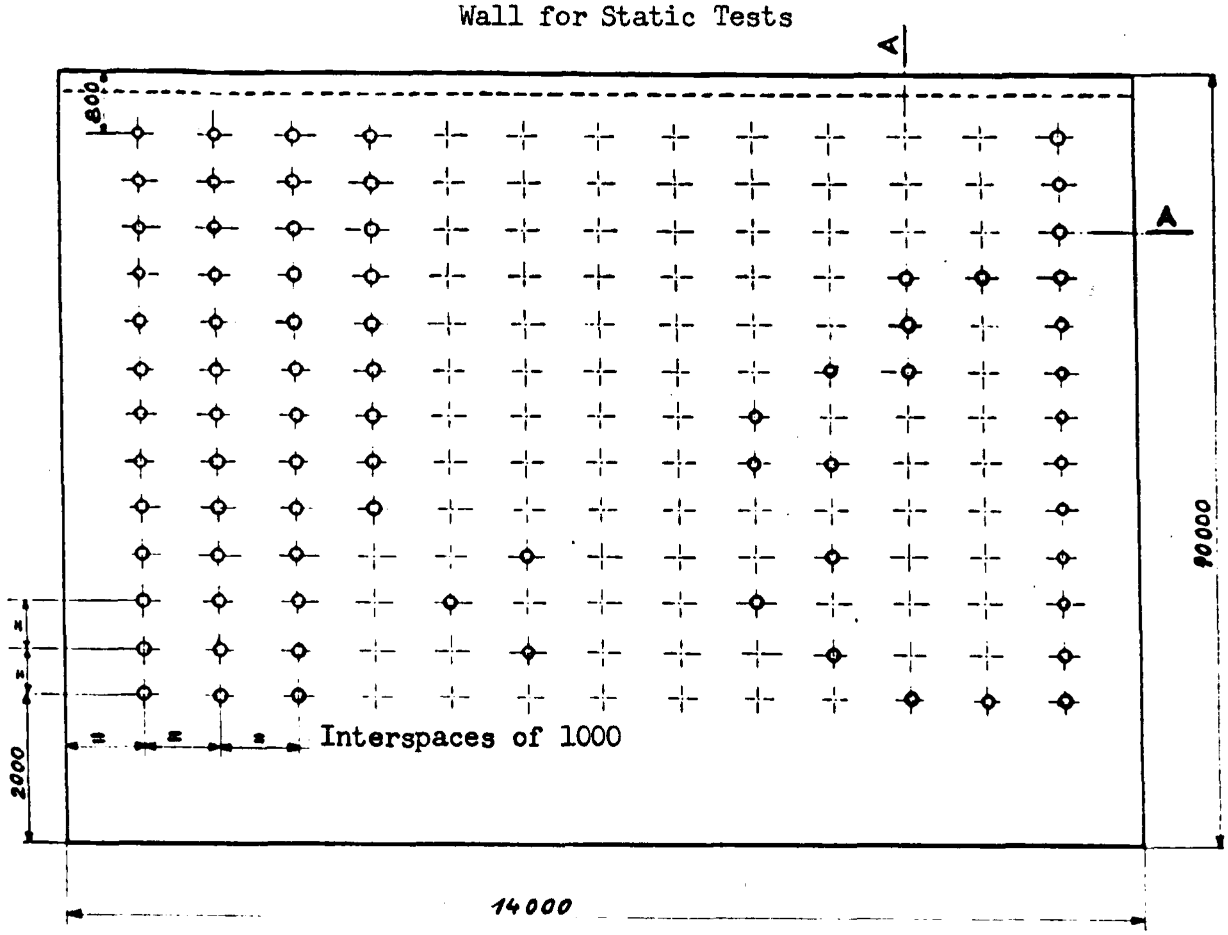
2 - Loads on the frame

2.1 - Vertical downward loads (compression).

2.1.1 - Local loads: 4×10^5 Newtons, working surface 2000 cm^2.

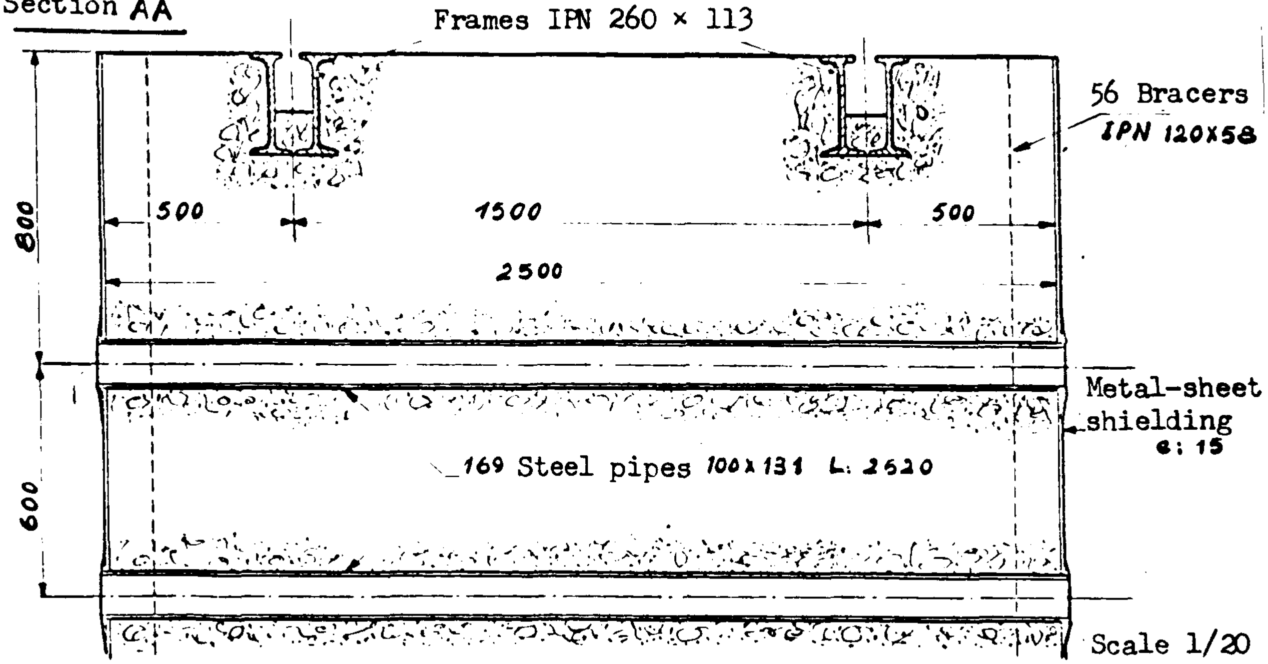
2.1.2 - Distributed loads: Permissible pressure 10^4 bars, on a maximum surface of 1000 m^2.

Wall for Static Tests



Scale 1/100

Section AA



Scale 1/20

A) - <u>Permissible loads on the steel pipes</u>

1 - Horizontal loads (along the pipe axes).

1.1 - Per reference point: 10^6 Newtons.

1.2 - On the entire panel: maximum moment 10^7 Nm (Newton meters).

2 - Intersecting loads (perpendicular to the pipe axes).

2.1 - Per reference point: 5×10^5 Newtons.

2.2 - On the entire panel: 4×10^6 Newtons.

B) - <u>Permissible loads on the upper cut-outs</u>

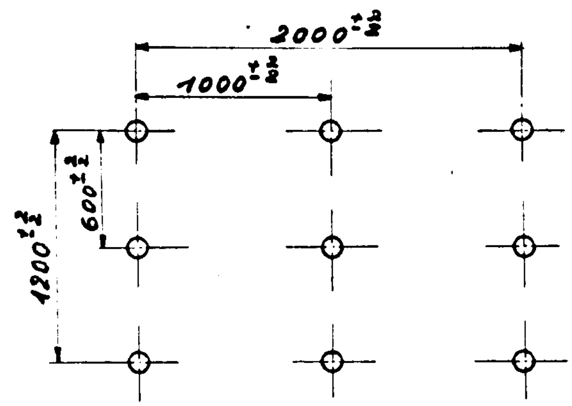
1 - Vertical loads, toward top or bottom.

1.1 - Point loads: 2×10^5 Newtons.

1.2 - For one cut-out: 5 times the point load.

C) - <u>Tolerances</u>

1 - Tubes



2 - Cut-outs: identical to the tolerances of the frame cut-outs.

Delegation of Ministry of Defense /1

Technical and Industrial Aeronautics
Administration

Aeronautics Establishment of Toulouse

23 Avenue André Guillaumet, Toulouse

HERS ANNEX

AIRCRAFT STRUCTURE TEST HALL

EQUIPMENT FOR MEASURING AND PROGRAMING

TECHNICAL SPECIFICATIONS LIST

TABLE OF CONTENTS

Page

Page

LIST OF ILLUSTRATIONS

/VI

Plan H1 004 1100	Ground Floor Plan
Plan H1 004 1101	Schematic Cross Sections
Plan H1 004 1200	First Floor Plan, Level 3.25 m
Plan H1 004 1300	Second Floor Plan, Level 6.97 m

CHAPTER I /1

TYPE OF EQUIPMENT, GENERAL PRINCIPLES

The Aeronautics Establishment of Toulouse (EAT) has been commissioned to make structural tests on supersonic aircraft and, therefore, will have to provide its testing facilities with the means for mechanical loading, heating, cooling, and measurements, as required for large-scale aircraft, flying at speeds above Mach 2.

No matter what technical solutions for heating, cooling, and loading might finally be accepted, it is indispensable to have available a measuring, control, and computer center, to serve two distinct functions:

1) Performance of the test in real time (150 heating zones, 30 loading groups, recording of 4000 measurements).

2) After completion of the test, work-up and editing of the results in a form readily accessible to the study offices.

This Center of instrumentation, control, and computing constitutes the basic item of equipment called for in this request for proposal.

In addition, the complete equipment can include auxiliary elements, going beyond the outlined supplies and equipment, as follows:

Elements for effective control of the power installation (solutions other than liquid rheostats).

Peripheral elements for the computer, other than those of the basic equipment (see Chapter V: Peripheral Equipment).

These parts of the installation must be separately presented and labeled, as has been specified in the administrative specs folder.

The submitted proposal may include variants, listed with price and possible delays.

In support of these versions, the bidder must submit technical substantiations and relevant financial data.

The overall scheme of the projected device (Fig.1) outlines the subject of the invitation to bid: /2

Principal equipment and supplies;

Auxiliary equipment and supplies;

Optional equipment and supplies.

These various categories are identified as P.E.; A.E.; and O.E. in the margin of the various Sections of Chapters II and V referring to these items.

Equipment and supplies is to mean the furnishing of the equipment itself, its erection, all connecting cables, check tests on the installation, and training of technicians of EAT.

The overall scheme shown in Fig.1 defines the projected system. Its individual elements are described in the following Chapters.

The primary important points are as follows:

1) The voltage levels for measurements differ:

   N_3 and N_4 are of the order of 1 to 10 v, full-scale;

   N_1 and N_2 are of the order of 0 to 20 mv.

2) If all measurements are recorded, only the values of N_2 and N_4 enter the calculation of the controls.

3) The "program" has two functions; one is to furnish, during the test, the numerical values required for its proceeding in real time and the other is to ensure the performance of calculation and the distribution of orders for the controls;

4) The limits of principal equipment and supplies are, on one end, the

commutation unit (inlet receptacles, comprising both male and female) and, on the other end, the supply of control voltages.

CHAPTER II 13

HEATING AND COOLING CONTROLS AND MECHANICAL LOADS

1. Operating Principle of Heating, Cooling, and Mechanical Loads

1.1 Heating

An aircraft flying at supersonic speed will heat up. During the structural tests, the simulation of this kinetic heating is obtained by heating with infrared emitters, arranged as a cover sheet or ring around the airframe under test.

The term "heat channel" or duct is to define a section of this sheet, formed by N emitters which have the function of producing a single heating program on a specific portion of the structure.

The subdivision into heating channels is based on considerations of structure homogeneity and localization of planking zones.

The infrared emitters of one and the same channel are subdivided into three groups, within which they are connected in parallel.

The power supply of the three groups is three-phase, over a transformer (output voltage: 220/380 v). With each of the three output phases of the transformer, a liquid rheostat is connected in series which permits varying the voltage at the terminals of the emitters.

The total number of heating channels is 150. Each individual duct is controlled separately and must follow a program. The maximum number of individual programs is 30 (the contents of such programs will be defined below), with the possibility of several channels having the same program.

1.2 Cooling

During the tests, the cooling of the airframe must be simulated.

This cooling is obtained by circulation of air, cooled by injection of liquid nitrogen (or by any other means).

The power of this air jet is not placed under control, but it must be 4
such that the cooling is greater than necessary so as to permit a regulation by reheating, using the infrared heaters.

In the present technical specifications manual, no further mention will be made of the cooling, its control being included in the programmation of heating fluxes and voltages.

1.3 Mechanical Loads

In flight, an aircraft is subject to a system of variable forces which must be simulated during the tests.

The mechanical loads are applied to the airframe by means of hydraulic jacks of 100 - 500 kN, operated by servo-valves.

The term "loading channel" or duct is to mean the unit formed by one jack and its servo-valve.

The maximum number of loading channels is 30.

Some of these channels can be symmetric; the number of individual loading programs is fixed at 20.

Each channel will have its own control.

2. Heating Controls

2.1 Notations

φ = thermal convection flux, in kw/m^2

h = thermal exchange factor, in kw/m$^2 \cdot {}^\circ$C

T_a = athermanous temperature, in $^\circ$C

T_s = local temperature of the structure, in $^\circ$C.

2.2 Simulation of Kinetic Heating

A definite flight program of the aircraft and a specific zone corresponds to a time rate of change of the quantities h and T_a.

The flux received by the airframe is

$$\varphi = h(T_a - T_s) .$$

Each heating channel must ensure realization of this flux. For this, h and T_a are programmed values while T_s is measured. The computer will furnish the computed flux.

This computed flux will be compared with the real flux. 15

Each heating channel thus will include a flux meter for measuring the real flux and a thermocouple for measuring the quantity T_s.

2.3 Characteristics of the Pickups Used

2.3.1 Flux Meter

O.E. The flux meter used will be the responsibility of the E.A.T.

The useful signal obtained from this flux meter is comparable to that of a thermocouple.

Variation range: 0 to 5 mv.

The flux meter can be assimilated to a first-order system, with a time constant varying between 0.5 and 1 sec.

Figure 2 gives the schematic diagram of a flux meter and its installation.

The meter will be placed at a point, yielding optimum indication of the mean flux of the heating channel.

2.3.2 Thermocouple

H.F. Type: Chromel-alumel.

Variation range: 0 to 20 mv.

The cold junction will be kept at zero degree in a refrigerated casing, while the hot junction can be either pasted or soldered to the structure.

The mounting of the thermocouple is shown in Fig.3.

The thermocouple will be placed in a location that yields the best indication of the mean temperature of the airframe skin zone, corresponding to the given heating channel.

The thermocouple, the refrigerated box, and their installation will be the responsibility of the E.A.T.

2.4 General Characteristics of Heating Control

This control procedure must be as simple as possible and as reliable as possible.

The cost of this installation must be reduced to the absolute minimum, since this unit is not in continuous use but only several hundred hours per year. Its maintenance must be easy.

All possible safety measures must be taken to prevent an accidental superheating that might destroy the airframe under test, the cost and the delay connected with its reconstruction being extremely high.

The control and maintenance must permit adherence to the prescribed value /6 to within 2% at maximum scale.

The installation must permit a ready control of proper operation of each heating channel, independent of the computer to be integrated later.

The E.A.T. proposes a solution which seems best suited to these conditions.

2.5 Description of the System Proposed by the E.A.T.

2.5.1 Power Control

O.E. The power will be furnished by transformers of 20,000/380 v, with three-phase output of 220/380.

A transformer (1250 kva power) will feed six heating channels.

The voltage at the terminals of the three emitter groups of one heating channel will be controlled by three rheostats which, in turn, are controlled by a single electric motor having a maximum power of 600 w.

The three circuits (one rheostat and one infrared emitter group, connected in series) will be connected in three-phase delta connection, with the neutral wire becoming earth return (see Fig.4).

The form of the rheostat plates will be such that the voltage fluctuation at the terminals of the emitters, as a function of the position of these plates, will be as linear as possible.

Appendix No.1 gives the technical specifications for liquid rheostats.

2.5.2 Controls, General Principle

P.E. The proposed device provides for voltage control. This control consists of two counteracting branches:

The first branching will provide for a coarse control.

The second branching will correct the first.

This system will provide for greater operating safety and will permit, before the test, a check on the proper functioning of the heating channels, without going over the computer (by elimination of the second branching).

The operating diagram for the controls suggested here is shown in Fig.5.

In this schematic diagram, the control voltage V_c is formed by two terms, /7 $V_{(oe)}$ and ΔV_c where:

$V_{(oe)}$ represents the estimated voltage

ΔV_c represents the resetting signal.

The quantity ΔV_c is produced in the computer and allows for the actual values of θ_{Rx} and T_s.

The quantities θ_{Rx} and T_s will be sequentially checked, placed at the desired level, and digitized.

The number of amplifiers required for ensuring proper operation of the 150 channels will be as small as possible. However, it must be sufficient for ensuring proper operating reliability.

The voltage V_i at the terminals of the infrared lamps of each individual channel must be recorded. This measurement is made in order to:

a) control, at the end of the test, the existing deviation from the program of estimated voltage, established before the test;

b) possibly integrate the quantity V_i in the calculation of ΔV_c.

2.5.3 Description of the Voltage Control Chain

2.5.3.1 Layout of the Control Voltage V_c

P.E. The control voltage will be obtained by a logical positioning of the relay contacts, yielding a cumulative value of the feed voltages.

The principal diagram is shown in Fig.6.

The overall unit will consist of a transformer with six secondaries. The number of relays, actuating K_1, K_2, ... K_6 will be six. This number permits $2^6 = 64$ possible combinations or 64 different voltage levels.

The instruction for positioning of the contacts K is given by the computer.

This logical positioning will take into consideration:

a) the programmed value $V_{(oe)}$;

b) the calculated value of the resetting voltage ΔV_c.

This will permit obtaining $V_c = V_{(oe)} + \Delta V_c$.

The prescribed value of V_c will be sequentially produced every 2 sec, on /8
each of the 150 channels.

The quantity ΔV_c need not be defined every 2 sec. Determination of the period of generation of ΔV_c is left to the supplier. The latter is to select a frequency such that the test program can proceed as smoothly as possible.

An auxiliary relay must make it possible to switch V_c to a test source of control voltage.

2.5.3.2 Voltage Regulation

Figure 7 gives the principal diagram for voltage regulation.

The voltage tapped from the terminals of the emitters is rectified, filtered, and placed in opposite phase to the control voltage V_c across a sensitive relay. Depending upon the direction of the voltage applied to its terminals, this relay must control the direction of revolution of the motor, shifting the moving plates of the rheostat.

This detector element can be a polarized relay, a galvanometric relay, or any other system ensuring the required function.

In all cases, the device must be rugged, simple, and of low cost.

The filters used must be such that no delays detrimental to proper functioning of the controls will be introduced.

The control voltage will be permanently in phase opposition with the voltage of the lamps, across the relay. This condition necessitates keeping the positioning of the contacts K between two successive values of V_c.

2.6 Specifications Required for the Proposed Controls

P.E. The controlling process must have an accuracy at least equal to 2% at the maximum of control voltage.

It must be possible to switch V_c to a standard voltage so as to perform the tests.

It must be possible to make all preliminary adjustments without going over the computer.

It must be possible to influence the overall level of the control voltage.

The proposed unit must be readily accessible and permit a rapid replace- /9
ment of any faulty part.

2.7 Characteristics of the Power-Chain Elements

2.7.1 Infrared Lamps

O.E. These are emitters of the 13195 X Philipps type, with tungsten filament. Their characteristics are given in the following illustrations:

Figure 8: Power absorbed by one emitter as a function of the voltage applied to its terminals.

Figure 9: Radiated power, as a function of time, for various voltage steps.

Figure 10: Resistance of the emitter filament, as a function of the voltage applied to its terminals.

2.7.2 Liquid Rheostats

O.E. The bidder is referred to Appendix No.1.

2.8 Data to be Furnished by the Supplier's Proposal

The supplier must study and give figures on a solution of the type proposed by the E.A.T.

The following items must be furnished:

The schematics showing the space requirements of the material and defining its accessibility;

Wiring diagrams of the various elements;

Principal diagrams of these elements.

In the technical details to be furnished by the supplier, the following must be indicated specifically: the conditions under which the control relays for V_c are actuated.

2.9 Limitation of the Equipment for Heating Controls

2.9.1 Solution Proposed by the E.A.T.

P.E. The principal equipment here is confined to a control of the reversing contact for the motor of the liquid rheostats.

This equipment comprises analysis, realization, erection, and checking of the installation.

2.9.2 Variants, Auxiliary Equipment /10

For the control elements, the bidder can propose possible variants. He must list the advantages and list the total cost of such variants.

As auxiliary equipment, the bidder is permitted to propose solutions other than liquid rheostats, for the power control. These solutions must be presented in a manner analogous to that specified for the principal equipment, indicating both price and time required for delivery.

3. Controls of Mechanical Loading

P.E. The types of jacks and servo-valves, for applying loads to the airframe, have not yet been defined and do not form part of the requested equipment.

The projected installation, for realizing these loading programs (and possibly also other necessary programs), will contain 10 outputs per relay, permitting 64 possible positions (same type as the relays for the V_c).

This unit will be supplied in a separate rack, whose cable connections will be made later by the E.A.T.

Each of the 10 outputs will be reset every 2 sec, by the input programs E (see Fig.5). Of the 10 inputs, five must have a device for limiting the degree of variation, for each resetting, to a value of 4 units (for 64).

These programs will be put under control.

For reference, see the loading program in Fig.11.

CHAPTER III /11

MEASUREMENTS AND CALCULATIONS REQUIRED FOR THE CONTROL OF THE TEST. POST-TEST COMPUTATIONS

1. General Data

1.1 During the Test

Three types of calculations must be made:

1) Calculations in real time, permitting the control of 150 voltage control ducts and the 10 logic output ducts.

The results of these computations will not be checked.

The purpose of such calculation is a sequential determination, for each heating duct, of the prescribed voltage value which must be established for realizing the control.

For the 10 auxiliary ducts their control must be synchronized with the course of the test.

2) Other calculations in real time will be performed and evaluated by a high-speed printer during the test.

These calculations will permit an overall control and a control of a limited number of measuring channels, selected before the test.

3) Calculations for checkup of reliable operation of the installation.

1.2 At the End of the Test

The stored quantities must be readable in accordance with their nature, in the form of temperature, stresses, deformations, and loads.

2. In-Test Computations

2.1 Voltage Control of Heating Channels

Notation

V = voltage at the emitter terminals (measured)

V_c = control voltage

$V_{(oe)}$ = estimated control voltage (programmed) /12

ΔV_c = resetting voltage, such that $V_c = V_{(oe)} + \Delta V_c$

φ_r = flux received at the flux meter (measured)

h = convection factor (programmed)

T_a = athermanous temperature (programmed)

T_s = temperature of the structure (measured)

$\Delta\Phi_R$ = defined by $\varphi_r - h(T_a - T_s) = \Delta\Phi_R$.

The purpose of this Section of to bring out the parameters that might be required in defining ΔV_c.

Depending on whether or not a flux meter is used for the controls, two types of computations must be made in real time.

Problem Formulation

Each heating channel is characterized by

a) its number of emitters N

b) its surface S

c) its yield η_k

d) its program.

a, b) The ratio $K = \frac{N}{S}$ furnishes the emitter density.

This ratio is a constant for each individual channel in the absence of emitter failure or dropout during the test.

For the overall structure, as homogeneous a distribution of the emitters as possible will be used; the ratio K will be more or less the same for all channels.

c) The quantity η_k denotes the overall output of the heating channel under consideration. The value of η_k during the test depends on various parameters of which the principal ones are the following:

voltage at the emitter terminals;

distance between emitters and reflectors;

distance between emitters and structure;

condition of the heated surface.

Figure 12 shows the variation of η_k as a function of the distance between emitters and structure, for a useful flux of 6 kw/m^2. The distance between emitters and structure will be about 200 mm, and η_k will be of the order of 0.35, for a useful flux of 6 kw/m^2.

This output will vary in the same sense as the useful flux (or the voltage applied to the emitter terminals).

d) Program. The test comprises the simulation of a flight program. /13

If this program is known, the values of h and T_a can be determined for each individual channel.

The control process must permit obtaining the following parameters at any instant of time:

for the first computational case, $\varphi_r = h(T_a - T_s)$,

for the second computational case, $T_a = T_s$.

It is desirable to perform a computation of the control voltage, yielding the reference voltage:

of the estimated control voltage $V_{(oe)}$, of the resetting voltage ΔV_c.

The estimated control voltage is introduced in the form of a quantity as a function of time, before the test. This voltage is correlated with the estimated flux by the relation

$$\Phi_e = \eta k \omega(Ve) .$$

In this equation, $\omega(Ve)$ denotes the power consumed by one emitter, as a function of the voltage applied to its terminals (see Fig.8).

This consumed power, in first approximation, is a function of only the quantity V. Such an assumption is justified if $\frac{dV}{dt}$ remains low during the entire test. This will be the case in the proposed tests (see the typical test programs, described in Chapter IV).

First Calculation Case

In a first type of control realized with the flux meter, the calculation to be performed will be as follows:

$$\Delta V = -\omega(V) \frac{dV}{d\omega} (V) \frac{\Delta\varphi_r}{\varphi_r}$$

while ΔV is correlated with ΔV_c by the relation

$$\Delta V_c = \lambda \Delta V$$

where λ is a constant, characteristic for the heating channel under consideration.

Under these conditions, we have

$$\Delta V_c = -\lambda\omega(V) \frac{dV}{d\omega} (V) \left[1 - \frac{h(T_a - T_s)}{\varphi_r}\right].$$

In order to prevent accidental overheating, the quantity ΔV_c must satisfy the condition

$$\Delta V_c \leq \Delta V_M$$

if

$$V \geq V_M .$$

In these expressions, all the quantities can be given, programmed, or measured: /14

Given	λ	(150 values); ΔV_M, V_M (10 values at most);
	$\omega(V)$	(one curve); $\frac{dV}{d\omega}$ (V) (one curve);
Measured	φ_r	(150); T_s (150); V (150);
Programmed	h	(30 programs); T_a (30 programs).

Second Case of Calculation

In some cases of tests, the control of the heating is performed without the use of a flux meter.

The required calculation will then be:

$$\Delta V_c = F(V)h(T_a - T_s)$$

with the condition

$$\Delta V_c \leq \Delta V_M$$

if

$$V \geq V_M .$$

In these expressions, we have:

Given quantities	F(V) (1 curve); ΔV_M, V_M (10);
Measured quantities	T_s (150);
Programmed quantities	h, T_a (30).

2.2 Data to be Furnished by the Supplier

It is possible that the bidder, for the elaboration of ΔV_c, will use other digital computation procedures such as, for example, derivation of iterative processes.

The supplier will indicate how he intends to realize ΔV_c and will define the time required for computation of each channel.

He will give the principle of deriving the control voltage V_c, permitting to realize a value of

$$V_c = V_{(oe)} + \Delta V_c$$

He will also define the principle of programing and indicate the influence of the computing of ΔV_c on performance of the controls.

2.3 Editing of a Limited Number of Test Points during the Test

A maximum number of 30 test points, selected before beginning the test, must be recorded on a high-speed printer during the test itself.

The observed quantities will include stresses, temperatures, and deformations.

The presentation of the results can be made in the form of editing groups (see Chapter IV). /15

The calculations are the same as those defined in Section 3 below.

2.4 Safety Measures; Control Computations

So as to ensure all safety measures for the tests, various controls will be performed.

1) Internal Control

This type of control refers to the total of the materiel, specified in this request for proposal. The definition of these control programs is left to the manufacturer; however, he must list the tested elements and functions, the recurrence of the test, and the consequences in case of detection of failure.

2) Controls Referring to the Test Installation

The calculations will exclusively concern threshold computations, referring to:

180 different values selected from the low-level group N_1 (see Fig.1).

These threshold values will remain constant for each individual value of each channel.

20 channels selected from the high-level group N_3 (see Fig.1).

As before, the thresholds are established before the test, with reference to one value per channel.

For these 200 measuring channels, the control tests will be made on the basis of the rough measuring data.

3) Threshold Computations

These computations will also be made on the 30 test points defined during the test.

2.5 Effect of Trouble Location

a) Any location of a fault must be immediately followed by cutting the contact (corresponding, for example, to stopping the heating of a given channel) and by flashing a light signal.

b) The trouble location program consists in varying the inputs E, thus controlling the operation of the hydraulic jacks.

In addition, the feed to all heating channels will be stopped. /16

3. Computation and Work-Up of the Results at the End of the Test

The data stored during the test are worked up and, on editing, must appear in the form of

temperature for the thermocouple channels;

deformations for the potentiometer taps;

stresses for the simple gages;

voltages for the voltage of the lamps;

forces for the strain pickups.

For the extensometric gages mounted in rosette form, the computations to be performed will determine the principal stresses and the principal directions.

3.1 Temperature - Deformations - Lamp Voltages - Forces

For these four types of measurements, the calculations will have the same form: multiplication of the coarse data by a constant.

For each of the types of measurement, the constant will be the same.

3.2 Stresses, Calculation of Rosettes

The calculation of simple gages and rosettes is given in Appendix 2.

3.3 Data to be Furnished by the Supplier

Taking into consideration the arrangement of the raw data before editing, the bidder must give the approximate time of complete reduction for a given test having a duration of 30 min (30 measuring channels are edited during the test). The cycle of the write-in base of the total of 4000 data will be 10 sec.

The flexibility of programming must permit partial data reduction varied, for example, as follows:

Interpretation of a certain number of data channels;

Interpretation of data exceeding certain thresholds, etc.

The bidder must indicate the influence of threshold computations (200 channels) on the cost price of the supplies.

He may propose a variant which does not have this particular arrangement.

In that case, he will make the same estimate for the computation and on-line data reduction for 30 data channels.

CHAPTER IV /17

TEST PROGRAM

1. General Data

The program to be stored in the computer, for ensuring proper performance of the test comprises:

1) Subprogram of write-in of the data;
2) Subprogram of processing, combining, and allocating the data;
3) Subprogram of checking and processing the data for the control process;
4) Subprogram of computation for heating controls;
5) Subprogram of instruction for 10 logic outputs;
6) Subprogram of checking, interpreting, and control of 30 selected parameters during the test;
7) Subprogram of checking and orienting all remaining data channels;
8) Subprogram of internal control;
9) Subprogram of equipment control;
10) Subprogram of down time.

2.1 Introduction of the Data

The operation of the system, for each cycle of 2 sec, requires the knowledge of 100 data as a function of time.

These data include:

30 estimated voltages $V_{(oe)}$, curve type shown in Fig.13;

30 athermanous temperatures T_a, curve type shown in Fig.14;

30 convection factors h, curve type shown in Fig.15;

10 miscellaneous parameters; example: possibility of realizing a load program, curve type shown in Fig.11.

These given curves are resolved into segments of straight lines so as to reduce the number of points representing each curve to a minimum.

Each individual datum must be represented by the equivalent of three decimal digits. /18

Time-independent data must be written in, as follows:

$$1^{st} \text{ case of calculation} \left\{ \begin{array}{l} 150 \text{ values } \lambda \\ \text{one curve } \omega(V) \text{ (see Fig.8)} \\ \text{one curve } \frac{d\omega}{dV}(V) \end{array} \right.$$

$$2^{nd} \text{ case of calculation} \left\{ \begin{array}{l} \text{one curve } F(V) \\ 10 \text{ values } V_M \\ 10 \text{ values } \Delta V_M \end{array} \right.$$

2.2 Subprogram of Processing, Combining, and Allocating the Data

This subprogram involves a linear interpolation between the points given, as a function of time, in the preceding Section. The subprogram starts from values obtained for each of the 150 service channels, after probable multiplication by a constant.

2.3 Subprogram of Checking and Processing of Data for Controls

This subprogram consists in call-in and shaping of the 150 necessary parameters, every 2 sec.

Storing for editing after the test (every 10 sec).

2.4 Subprogram of Calculation for Heating Controls

This subprogram consists in calculating the 150 ΔV_c (see Chapter III) on the basis of data and measurements, at least every 6 sec.

Computation of 150 V_c;

Setting of 150 outputs per relay, every 2 sec.

2.5 Subprogram of Instruction for 10 Logic Outputs

This subprogram sets the 10 outputs every 2 sec.

2.6 Subprogram of In-Test Checking, Interpretation, and Control of 30 Selected Parameters; Work-Up Every 10 Sec

The tests on these 30 parameters will be made every 2 sec. The computations and the editing of the 30 parameters will be made every 10 sec.

2.7 Subprogram of Checking and Orienting of the Remaining Data Channels

The basic cycle is fixed at 10 sec.

The checking cycle can be a multiple of 10 sec (in the case of long-time tests, referring to pulse tops of heating and loading). /19

The measured quantities will be oriented and accompanied by a clock pulse.

2.8 Subprogram of Internal Control

This subprogram will be defined by the bidder who will also indicate what actions might possibly be released by this check test.

2.9 Subprogram of Built-In Check

This subprogram consists in the call-in of the 200 checked data (180 + 20), with the call-in cycle of each channel being 10 sec; threshold computation every 10 sec.

2.10 Subprogram of Diagnostic Test

This subprogram is started after completion of the tests on the principal elements of the test installation. Among other functions, this subprogram will

actuate the 10 E outputs, controlling the dump;

stop the heating.

3. Data to be Furnished by the Supplier

The bidder must specify the process of write-in of the program and the data.

He must indicate in each case the advantage resulting from the proposed solution.

In all cases, the following requirements must be met:

Facility of write-in;

Definition of a solution limiting the time of write-in and data preparation;

Reliability of operation (extremely important).

CHAPTER V /20

DATA HANDLING

1. Definition of the Terms Used

Data Channel: The unit is composed of an encoder (strains, deformation, or temperature) and the cables for connecting with the central processor.

Reference Channel: Separate channel connected to a reference voltage. This channel is used for calibrating and checking the amplifier gains.

Editing Group: Format given to the information in editing the results. An editing group comprises:

A clock pulse,

An identification number,

A fixed number of test points of the same level.

Switching Unit: The overall unit permits checking of a large number of channels (for example, 500).

Each switching unit comprises:

A relay unit for switching;

Required amplifier or amplifiers;

Required analog-to-digital converter or converters;

One reference channel.

The number of channels per switching unit is left up to the discretion of the bidder and can be varied in accordance with the material presented.

The overall installation will contain the necessary number of switching units for switching 4000 data channels.

2. Editing the Results /21

P.E. The editing of the results is done in the form of editing routines, each routine comprising the following:

2.1 Recording of Absolute Time

The unit will contain a clock whose starting and stopping must be controlled independently of the start of the program.

The recorded time will be characteristic for the specific editing routine, for example for the first datum. The digit representing the time must be given in seconds.

2.2 Calibration of the Editing Group

A first digit will indicate the switching unit to which the group belongs.

A second digit will identify the editing group within the switching unit.

This system is merely suggested and the bidder is free to define any other means of readout.

2.3 Write-in of the Data

The number of test points written-in per editing group must be a multiple of 4 (16, 20, or 24 points, for example).

The data referring to each editing group must be at the same level.

Each editing routine will thus have the following format:

```
        Time              Readout              4 p Data
|---------------|   |---------------------|   |------| |------| — — — |------|
```

The editing of the results must be made on a high-speed printer with alphanumeric printing.

The number of characters of this printer must permit printing one editing group per line.

A period of data reduction of 15 hrs is permitted for a test of 30 min, with continuous write-in every 10 sec.

The editing must also be possible on punch tape.

3. Inputs /22

The total number of data channels must be 4000 (see Chapter III).

The Table gives a compilation of the various data, the processing, and the sequence of checking these data.

Function	Total Number	Level	Number	Checking Sequence	Sequence of Threshold Computation	Storage	Computation and Editing
Controls	450	220 v (5 or 10) (or 20 mv)	150 300	2 sec 2 sec		10 sec 10 sec	after test
1st Check	30	10 or 20 mv 10 v	20 10	2 sec 2 sec	2 sec 2 sec	10 sec 10 sec	10 sec 10 sec
2nd Check	200	10 or 20 mv 10 v	180 20	10 sec 10 sec	10 sec 10 sec	10 sec 10 sec	after test
Data	3320	10 v 10 mv 10 or 20 mv	180 1600	10 sec 10 sec 10 sec		10 sec 10 sec 10 sec	after test

These figures give an idea of the overall distribution of the data channel.

The supplier will adapt his switching units, allowing for their technology, so as to approach as much as possible the above distribution.

3.1 Organization of the Data Channels; Compensator Cabinets

O.E. To obtain a homogeneous data-handling equipment, all data channels will terminate in input cabinets, except possibly the channels for high and medium level data. Furnishing these cabinets is the responsibility of the Établissement Aéronautic de Toulouse.

For the extensometric gages, these cabinets will contain the necessary /23 Wheatstone bridges and the balancing device for the bridges.

Figure 16 gives the principal wiring diagram of the balancing of a gage channel.

4. Elements of the Commutation Unit

4.1 Inputs

P.E. The inputs are connected to receptacles defined by the supplier who also will furnish both male and female plugs.

4.2 Reference Voltage

P.E. The reference voltage, independent of the remainder of the installation, will be supplied by the supplier, in terms of one voltage per switching unit. The reference voltage level will be selected by the supplier.

This reference voltage must permit a ready check on the gain and on the reliable operation of the data chain.

4.3 Data Extracting

P.E. The stray currents, influencing the data, must be damped by filtering.

The supplier is requested to furnish a priced solution, comprising one filter per channel and permitting an attenuation of at least 40 decibels for a frequency of 50 cycles.

The bidder is permitted to submit, as a variant, any other solution which will have a smaller number of filters. In this case, he must specify the conditions of this filtering and give all necessary information for rating its efficiency.

4.4 Switching Relays

P.E. Selection of the Relays is left to the supplier who must indicate the brand, type, and characteristics.

These relays must be readily accessible for possible replacement.

The switching must proceed by closure of two contacts.

4.5 Amplifiers

P.E. The bidder must furnish the characteristics and performance curves of the proposed amplifiers. He will specifically indicate the recovery time in the /24 case of cutoff of the thermocouple.

Input scales: ±5 mv; ±10 mv; ±20 mv.

The amplification instruction must be given before the test, in terms of one gain for each editing group, remaining constant over the entire test.

4.6 Analog-to-Digital Converters (ADC)

P.E. Such converters must be sufficient in number to ensure satisfactory reliability of the overall unit. The converters must furnish the sign of the bit (at least, in the case of stresses and strains) and the equivalent of three decimal digits.

The supplier will furnish the characteristics and performances of the proposed analog-to-digital converter.

5. Computer

P.E. Continuous power supply of 20 kva will be furnished by the E.A.T. This supply will ensure a voltage stability of ±2% and a frequency stability of -1% to +0.4%.

The choice of the computer is left to the bidder who must submit all necessary information to rate its facility of use.

Outside of the testing periods and data reduction times, the computer must be useful for checking various test routines.

The bidder will indicate under which form the programing is to take place and will furnish several examples.

Program write-in will be by punch tape.

The elements of the memory must be laid out so as to permit storage of all data obtained during a given test of 30 min, with continuous recording in terms of 4000 bits every 10 sec.

In the case of longer tests, the recording will no longer be continuous but interrupted by nonrecording periods of pure bits whose duration (multiples of 10 sec) and frequency must be programed before the test.

The number and type of the memory elements and of the transfer elements are left to the discretion of the bidder.

For each of these elements, the supplier must furnish the necessary wiring diagrams, characteristics, performances, and memoranda as to maintenance and debugging. /25

For the computer, the bidder must also furnish all documents listed in the preceding Section, as well as the nomenclature of the programs, and the cost of systematic preventive maintenance.

6. Peripheral Equipment

P.E. This equipment comprises:

An input and output typewriter, connected to a perforator and to a tape reader;

An input unit by punch tape;

An output unit by punch tape (standard, 8 tracks);

A high-speed printer (permitting the printing of an entire editing group on a single line);

A memory unit for storing the data.

For each of these elements, the bidder must furnish the necessary wiring diagrams, characteristics, performance data, and maintenance and debugging memoranda.

7. Miscellaneous

A.E. In addition to the peripheral equipment described above, the bidder must furnish the characteristics and the cost of the following units:

XY plotter. The supplier must give the possibilities of coupling this unit with other peripheral elements.

Card reader and card punch combined with its coupling element.

Various visual display elements.

8. Data Furnished by the Supplier

For each of the suggested solutions, the supplier is to furnish diagrams of the proposed installation. These diagrams must be lettered.

The supplier must specify the cable connections for the various elements.

The accessibility of the various elements must be excellent.

The bidder must also indicate the mode of branching of the various ele- /26 ments. Branchings by receptacles are preferable for the overall installation.

The supplier must define the proper maintenance conditions for the various units of the proposed installation.

He also is to indicate the power consumed by the entire installation.

He is to define the guarantee conditions and indicate the proper stationing of repair crews.

CHAPTER VI

LOCALITIES AND INSTALLATIONS

1. General Principles

The installation of the materiel, listed in this request for proposal, will be done in a building still under construction (see plan Nos. H 1 004 1100; H 1 004 1200; H 1 004 1300; H 1 004).

The conditions imposed by the layout selected for these localities are defined in the following Sections. If modifications of this substructure would become necessary relative to the proposed equipment, this point must be covered in the price quotation.

The airframe under test will be placed along the axis of the hall. Taking into consideration the shape of the aircraft and the necessity of controlling specific zones, about two thirds of the test points will be located in the hatched portion of the tested unit (see plan H 1 004 1100).

The data cables will run through the transverse hallways and then through the longitudinal hallway, from where they are led upward into the measuring room of Building A, through a duct installed for this particular purpose.

The feeder cables for the reflectors and the hydraulic conduits will run through the transverse hallways, along the basement of the transformer room (Building B), and return to the transformer room or the control room through openings provided for this purpose in the floors, along the glass partition.

The connections between the control room and the measuring room will run through the outer cross hallway, toward the east side. The cabling will be placed into protective sheaths to prevent interference with other circuits;

these cable sheaths must be defined by the supplier.

2. Data Handling Room /28

In Building A, three rooms are scheduled for the installation of the data-collection and computer center.

2.1 First Room, or Data Pickup Room

Dimensions: 15 × 7 m, height to ceiling 3 m, air-conditioned.

This room is set aside for pure data-collecting circuits, containing the following:

Inlet and compensator cabinets;

Switching units with filters, amplifiers, and converters.

2.2 Second Room, or Programing Room

Dimensions: 8 × 5 m, height to ceiling 3 m.

This room is set aside for data-collecting circuits used in the programing and containing:

Inlet and compensator cabinets;

Switching units with filters, amplifiers, and converters.

2.3 Third Room, or Data Reduction Room

Dimensions: 14 × 7 m, height to ceiling 3 m, facilities for air conditioning.

This room will contain the following:

computer proper;

memory unit;

peripheral equipment of the computer;

two offices;

filing facilities.

2.4 Layout of the Various Rooms

The distribution of the materiel, defined in the preceding Sections, is given only as a general guide. The supplier will organize these three rooms so as to make the best possible use of the floor space and to provide ready access to the instruments and circuits for convenient monitoring and maintenance.

A double floor is permissible, if such a solution would facilitate laying of the cables.

3. Control Room /29

The transformers and liquid rheostats will be placed in the room located along the large hall and having a floor space of 67 × 14 m (height to ceiling 6 m).

The transformers will be arranged along the outside wall, and the liquid rheostats will be placed along the partition between the room and the testing hall.

The control room (air-conditioned) is located above the transformer room and has a floor space of 33 × 7 m (height to ceiling 3 m).

This room is to be used as the control post during the tests.

In addition to the equipment listed in this request for proposal (specifically all control units described in Chapter II), the E.A.T. will install consoles, visual-display panels, two large tables, and a filing cabinet.

The final layout of the control room cannot be definitely fixed before completion of study of most of the problems on the performance of tests with the Concord aircraft.

The glass partition, facing the testing hall, must remain unobstructed so as to retain total visibility.

A double floor can be installed if such a solution would facilitate laying of the cables.

4. Observation

Placing the measuring room at some distance from the control room was intentional, to avoid interference of the power circuits with the data-collecting circuits.

If the bidder is of the opinion that such interference is not to be feared, he is free to propose installation of the entire equipment of the control room in the intermediate rooms (scheduled now as dressing rooms and shop stockroom).

The supplier is also free to suggest placement of some switching units in the control room, if this does not create a major problem of excessively long connections between these units and the computer.

5. Power Supply /30

A continuous power feed unit is scheduled for supplying the data-collecting and programing equipment.

The supplier must indicate the type and positioning of the receptacles and safety fuses required.

This power line is independent of the supply line to the power units and of the electric mains.

APPENDIX NO.1

/31

LIQUID RHEOSTATS; TECHNICAL SPECIFICATIONS

1. Constitution of a Heating Channel

One heating channel controls a maximum power of 300 kva, i.e., 100 kva per phase. Figure 4 shows the layout of a typical heating channel.

The installation comprises 150 channels, i.e., 450 single-phase rheostats.

Three rheostats of the same phase are controlled by a single motor, actuated by the control chain of the channel under consideration.

The electric power is furnished by 25 transformers of 1250 kva, providing a 50-cycle three-phase current of 220/380 v.

2. Principal Characteristics of a Rheostat

As electrolyte, regular city water or treated water (low dosage) is used.

Feed Voltage of the Emitters

The voltage fluctuations at the terminals of the infrared emitters, as a function of the position of the plates, is to be practically linear. This voltage will vary from 0 to 220 v.

Rate of Displacement of the Plates

The time of displacement of the plates between open position (infinite resistance) and closed position (resistance near zero) will range between 10 and 15 sec.

Power of Control Motor

The control motor for the three rheostats of one and the same channel will have a maximum power of 600 w.

Water Circulation

The circulation of water will be adjusted so that the maximum heat-up is limited to 15° C.

Short-Circuit at the End of the Run /32

So as to obtain the maximum possible voltage at the terminals of the emitters, a device will be provided for short-circuiting the rheostat as soon as the plates have reached the stop, in closed position.

Safety Measures

Terminal cutout switches;

Circuit breakers at the inlet;

Luminous signals indicating start-up of voltage.

APPENDIX NO.2 /33

MEMO ON COMPUTATION NO.1

STRAIN MEASUREMENTS BY POTENTIOMETER PICKUPS

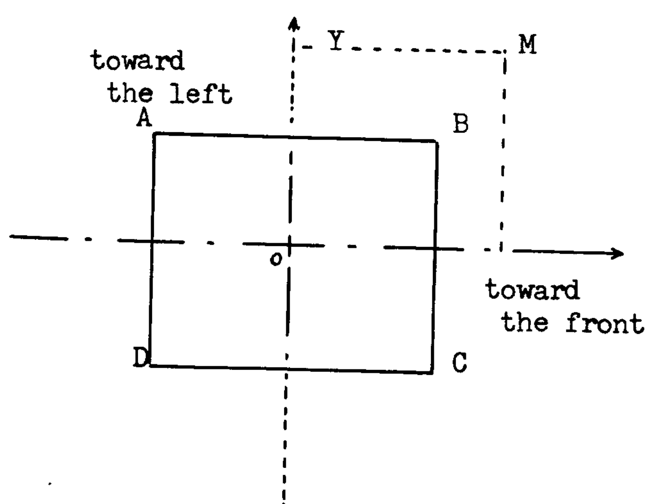
Under the action of loads, the test aircraft will shift and deform. In this memo, only vertical shifts and deformations will be considered.

The pickups, placed on different points of the aircraft, record the coarse values representing the total of shifts and deformations:

$$Z_c = Z_s + Z_d .$$

Calculation of Z_s

A reference square is defined, such that the deformations to the right of the apices are zero or negligible.



Here, OX is the aircraft axis; OY is the vertical axis, AB = m, BC = n.

Let a, b, c, and d be the data of the points A, B, C, D, i.e., the displacements.

The displacement of a point M of the coordinates X and Y will then be

$$Z_s = \frac{a + b + c + d}{4} + \frac{x}{m} \frac{(b + c}{2} - \frac{a + d)}{2} + \frac{y}{n} \frac{(a + b}{2} - \frac{c + d)}{2} .$$

Calculation of Z_d

The deformation at the point M will be

$$Z_d = Z_c - \frac{a + b + c + d}{2} - \frac{x}{m} \frac{(b + c}{2} - \frac{a + d)}{2} \frac{y}{n} \frac{(a + b}{2} - \frac{c + d)}{2} .$$

For all measurements, m and n are constant. /34

For one load pulse top, the quantities a, b, c, and d are constant.

One pickup is defined by its coordinates x and y.

Z_c, a, b, c, and d are defined with respect to the position of the aircraft under zero load and are positive toward the top.

x is positive for a point located toward the front while y is positive for a point located to the left of OX.

All these values are thus algebraic and must be written into the computer with their sign.

Note:

The computation of Z_d is performed after the test.

The values a, b, c, and d must be maintainable during the test, i.e., must be edited.

In some test cases, the horizontal deformations, parallel to the OY axis, must be measured. In these cases, the reference square is vertical and located in the ZOX plane. The calculations are identical.

The data reduction is made in the form of a double-input table: reference marks of the pickups and number of the pulse tops.

APPENDIX NO.3

MEMO ON COMPUTATION NO.2

STRAIN MEASUREMENTS (CALCULATION OF GAGES AND ROSETTES)

1. Correction of Gages as a Function of Temperature

The measurement made with an extensometric gage must be corrected to allow for the temperature effect on the gage factor K and to introduce the apparent stress $\left(\frac{\Delta R}{R}\right)_a$.

A thermocouple is combined with each gage.

The raw data of the pickups are first translated into resistance variation $\frac{\Delta R}{R}$ (gages) and into degrees θ (thermocouples).

The formula, yielding the degree of elongation to the left of the gage, reads

$$\frac{\Delta L}{L} = \frac{1}{\alpha K}\left[\frac{\Delta R}{R} - \left(\frac{\Delta R}{R}\right)_a\right]$$

where

K = gage factor (constant for one type of gage);

$\frac{\Delta R}{R}$ = relative variation of the resistance, recorded;

α = correction factor of K, as a function of θ;

$\left(\frac{\Delta R}{R}\right)_a$ = apparent stress, as a function of θ.

The quantities α and $\left(\frac{\Delta R}{R}\right)_a$ are derived from two curves (as a function of θ), defined by eight points and by interpolation between these eight points. For all gages of the same type, these curves will be identical.

Knowing θ and $\frac{\Delta R}{R}$, we can then calculate:

$$\frac{\Delta L}{L} = \frac{1}{\alpha K}\left[\frac{\Delta R}{R} - \left(\frac{\Delta R}{R}\right)_a\right].$$

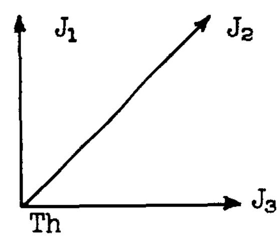
The computations will be performed after completion of the tests (except, possibly, for a very limited number of gages). The results are edited in the form of Tables of various presentation, depending on the tests. Generally, $\frac{\Delta R}{R}$ and $\frac{\Delta L}{L}$ are given together. /36

These Tables, for a given temperature or for a given load factor, can show the values of the total stress.

The same Tables, for a given gage, can show the magnitude of the stresses as a function of the temperature, or of the mechanical load factor, or of both.

2. Calculation of Rosettes

The rosettes used comprise three gages, laid out at an angle of 45°. Each rosette is combined with a thermocouple.



For each of the gages, as in Section 1, we calculate

$$\left(\frac{\Delta L}{L}\right)_1, \left(\frac{\Delta L}{L}\right)_2, \left(\frac{\Delta L}{L}\right)_3 .$$

Then, the abscissa of the center of Mohr's circle is calculated:

$$u = \frac{\left(\frac{\Delta L}{L}\right)_1 + \left(\frac{\Delta L}{L}\right)_3}{2}$$

and the radius of this circle:

$$v = \sqrt{\left[\left(\frac{\Delta L}{L}\right)_2 - u\right]^2 + \left[\left(\frac{\Delta L}{L}\right)_3 - u\right]^2} .$$

The principal deformations are

$$\epsilon_x = u + v \ ,$$

$$\epsilon_y = u - v \ .$$

The angle, made by the principal axis, is

$$\sin 2\alpha = \frac{\left(\frac{\Delta L}{L}\right)_2 - u}{v} \ .$$

The quantities $\frac{\Delta L}{L}$ are algebraic values and thus are taken with their sign.

Denoting by φ the angle through which the direction $\left(\frac{\Delta L}{L}\right)_1$ must be turned to make it coincide with the principal direction ϵ_x, and taking the trigonometric sense as the positive sense of the angles, we obtain

$$\varphi = -\alpha \qquad \text{if } \left(\frac{\Delta L}{L}\right)_1 \geq \left(\frac{\Delta L}{L}\right)_3$$

$$\varphi = \alpha - \frac{\pi}{2} \quad \text{if } \left(\frac{\Delta L}{L}\right)_1 < \left(\frac{\Delta L}{L}\right)_3 \ .$$

On the other hand, if $|v| < \left|\left(\frac{\Delta L}{L}\right)_2 - u\right|$ or if $v = 0$, divisibility by zero must be provided. /37

The results to be furnished in the form of a Table will be

$$\theta, \left(\frac{\Delta R}{R}\right)_1 \left(\frac{\Delta R}{R}\right)_2 \left(\frac{\Delta R}{R}\right)_3$$

$$\left(\frac{\Delta L}{L}\right)_1 \left(\frac{\Delta L}{L}\right)_2 \left(\frac{\Delta L}{L}\right)_3$$

$$\epsilon_x \qquad \epsilon_y \qquad \varphi \ .$$

MINISTRY OF DEFENSE

TECHNICAL AND INDUSTRIAL AERONAUTICS ADMINISTRATION

AERONAUTICS ESTABLISHMENT OF TOULOUSE

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Toulouse

/1

HERS ANNEX

AIRCRAFT STRUCTURE TESTING HANGAR

POWER CONTROL BY DRY THYRATRON UNITS

TECHNICAL SPECS FOLDER

TABLE OF CONTENTS

/2

LIST OF ILLUSTRATIONS

I. TYPE OF EQUIPMENT, GENERAL PRINCIPLES

The E.A.T. has been commissioned to perform mechanical loading, heating, and cooling tests on full-scale aircraft structures in its testing facilities at Hers.

These tests have the purpose of flight simulation of such aircraft.

To simulate the kinetic heating of the structure in the case of supersonic flight, a heating strip or sheet, formed by infrared emitters, is placed around the airframe. The heating control is done by programation, with an integrated computer directing the entire unit.

The heating strip or sheet is subdivided into individual heating channels; each channel is independent and the computer ensures control of each.

The present request for proposal covers the study and realization of a power control system, permitting the supply of each heating channel with variable voltage.

The elements for power supply, as specified in this request for proposal, are dry thyratrons.

The units performing such control are of two types:

1) Units directing heating channels with a power consumption of 50 kw each;

2) Units directing heating channels with a power consumption of 200 kw each.

The project comprises the equipment and installation of 75 independent units, feeding 75 heating channels.

The distribution of these is as follows:

20 heating channels .... 50 kw;

55 heating channels .... 200 kw.

A final auxiliary group of 150 units will permit the control of a total power of 30,000 kw. 15

II. CHARACTERISTICS OF THE HEATING CHANNELS

2.1 Definition

Each heating channel is formed by infrared emitters, mounted to reflectors. The I.R. tubes of a given channel will be of the same type. On each such heating channel, the tubes will be connected in parallel.

2.2 Characteristics of the I.R. Tubes

Three types of I.R. tubes can be used.

The attached diagrams give the principal characteristics of each type of tube.

Power consumed, as a function of the terminal voltage: Figs.1, 2, 3;

Resistance of one tube, as a function of the terminal voltage: Figs.1, 2, 3;

Current response to voltage steps: Figs.4, 5, 6;

Response time of the infrared tubes: Fig.7.

III. CHARACTERISTICS OF THE ELECTRIC POWER SUPPLY (BY THE E.A.T.)

3.1 General Principles

The dry thyratron units will be fed by transformers having a rated power of 1250 kva.

The plan No. GT 810 301 indicates the placement of these transformers. The total number is 25.

3.2 Characteristics of the Power Transformers

Primary: 20 kv - tolerances in accordance with the U.T.E.C. 52.100 Standard.

Secondary: rated voltage, 400/232 v.

Regulator sockets are provided at the primary to obtain a voltage of /6
380/220 at the secondary.

The connection is of three-phase Y connection, with neutral output, and four terminals.

3.3 Overload Protection

Each transformer contains a protective low-voltage cell, supplemented by six segmental circuit breakers (see the layout in Fig. GT 810 301 a).

Each circuit breaker is of the three-pole trigger type, with sectioning of the neutral pole, type DVR 800 amp, having a cut-out power of 50,000 amp at 380 v. Omnipolar tripper, which can be regulated from 320 to 500 amp, is used.

Behavior toward Overloads

The transformers are able to resist an overload corresponding to 2700 amp, for 3 min.

Sudden Short-Circuits

The transformers are laid out for resisting a three-phase short-circuit at the terminals of the secondary, no matter what the regulation at the primary might be. If the primary voltage is maintained, the duration of the short-circuit may be as long as 3 sec.

IV. CONTROL OF THE DRY THYRATRON UNITS (FURNISHED BY THE E.A.T.)

The control signal is incremental and is generated in the control room (see plans H 1 004 1100; H 1 004 1300).

The control signals can be furnished either by relay contacts or directly at the output of a transistorized amplifier.

The control of each individual heating channel is independent.

The element of the control instruction output of the dry thyratron unit comprises:

An address logic element, with 75 addresses; /7

A control system, ensuring execution of the instructions and of the addresses of the output commands;

A time base, determining the time of closure of the relay contacts of each heating channel;

Logic decision circuits.

The overall unit is controlled by a computer which, every 2 sec, determines the number of pulses (contact closure) to be fed to each "dry thyratron" unit.

The computer releases the pulse feeding at regular time intervals, for a duration of 2 sec, for each individual heating channel.

The computer simultaneously controls three units.

Figure 8 gives a schematic diagram of the development of the instruction sequence.

V. FEEDING THE HEATING CHANNELS BY THE "DRY THYRATRON" UNITS

5.1 Power Section

The supplier will furnish a homogeneous distribution of the 50- and 200-kw units for each power transformer. The supplier will also install six units per transformer, connected to six segmental cutouts.

The control units for the 75 heating channels will be grouped in cabinets which must be readily accessible for possible replacement of the various elements.

Each such cabinet must be ventilated.

A project for combined ventilation of all units can be submitted as an appendix, with the fresh-air intake through the basement.

The plans Nos. GT 810 301 A and H 1 004 1101 give the location of the /8 basements and the layout of the openings provided between transformer room and basement.

The temperature of the transformer room must remain below or equal to 30° C.

The ventilation of each dry thyratron unit must permit sufficient cooling, to prevent limitation of operation at rated power.

The supplier, in his proposal, must furnish the characteristics for the dry thyratron output, as a function of temperature.

He will also indicate the magnitude of the idle current. This idle current must introduce only negligible heating power into the infrared tubes.

Safety devices must be included with the dry thyratron units, to protect them from the effects of possible failure.

The main protective devices considered, primarily concern the following:

Current on voltage cut-in;

Short-circuits;

Instantaneous overvoltage (for example, lightning).

The characteristics of the I.R. tubes will yield all necessary computational elements.

Signaling of certain types of "dropout" can be provided.

5.2 Control Section

The trippers necessary for the dry thyratron control are placed close to these thyratrons so as to prevent, as much as possible, transfer of steep-front wave trains.

The supplier will also furnish the operating principle of a tripper, /19
together with its electric characteristics.

5.3 Presentation of the Materiel

The power output of the dry thyratron units can be over terminal boards, in terms of four terminals for each heating channel.

The control input for the dry thyratron units will also be over terminal boards.

The supplier, in his proposal, will furnish a layout for the cabinets and a diagram for their erection.

5.4 Cable Connections

Furnishing and installing the cables, connecting the segmental circuit breakers with the dry thyratron units, is the responsibility of the contractor.

Furnishing and installing the cables, connecting the control room with the input terminals of the circuit breakers, also is his responsibility.